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**APPENDIX B**

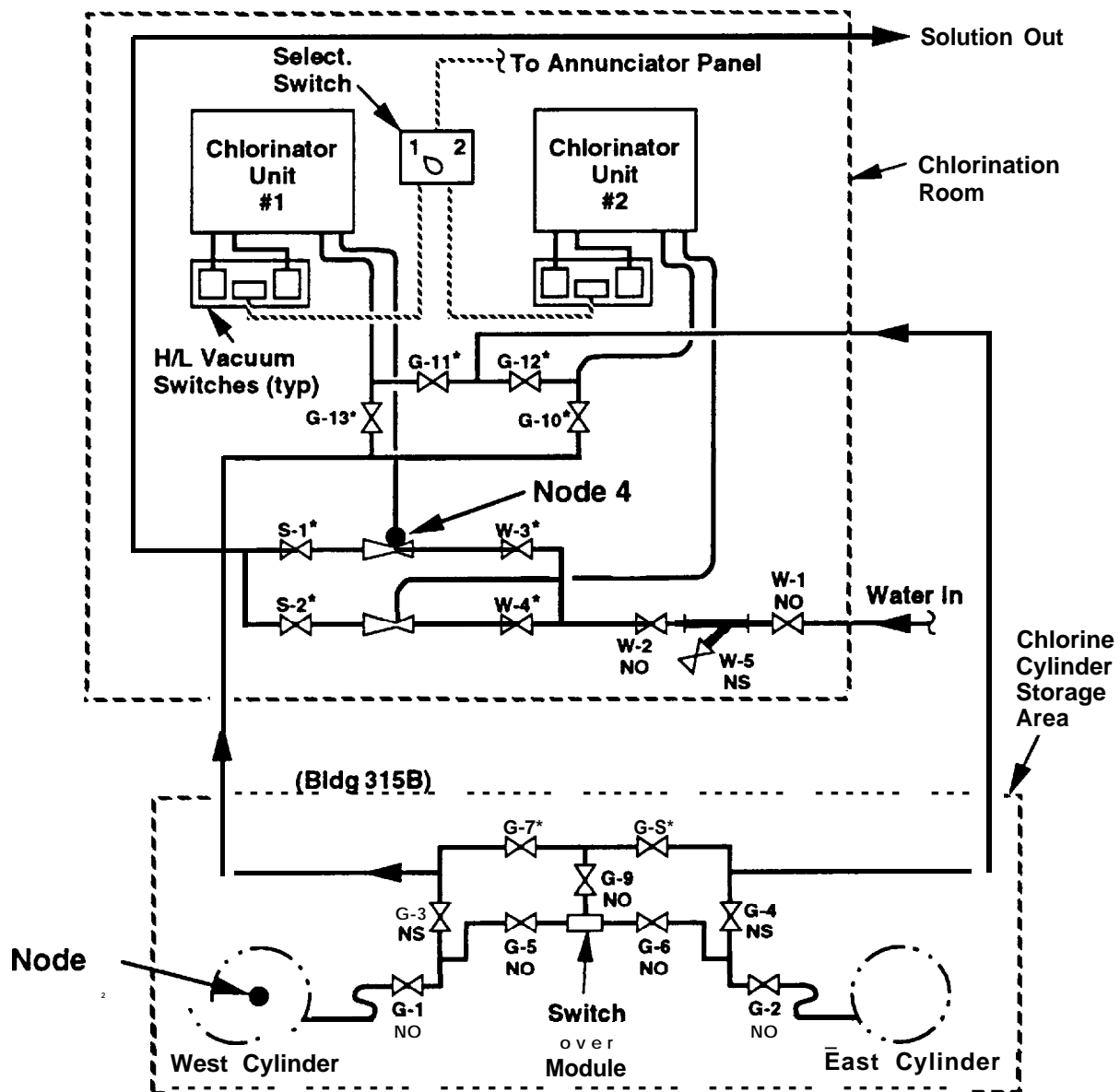
**HAZOP STUDY WORKSHEETS**

## APPENDIX B: HAZOP STUDY WORKSHEETS

Two independent chlorination systems are installed at the Hanford 300-Area Water Treatment Facility. These systems can be operated separately or in parallel. Because they are normally operated separately, this HAZOP study assumes only chlorination system #1 is operating, and that valves G-12, G-11, G-10, G-8, G-4, G-3, S-2, and W-4 are closed.

The following worksheets document the HAZOP study. The chlorination process was separated into four study nodes. These four nodes are shown on Figure B-1 (**Nodes 2 and 4**) and Figure B-2 (**Nodes 1, 3, and 4**). Nodes 5 and 6 cover the procedures for change-out of chlorine cylinders (see Appendix A).

The HAZOP worksheets for the six nodes use HAZOP guide words to determine possible deviations from process design conditions. Causes are **described**, including positive and negative human factors influences (“**+HF**” for positive influences and “**—HF**” for negative influences). Consequences of accident scenarios are estimated qualitatively for each process deviation. Protection and mitigating **factors** are described, including positive and negative human factors influences. The action/comment column includes both action items and justifications for no further action.

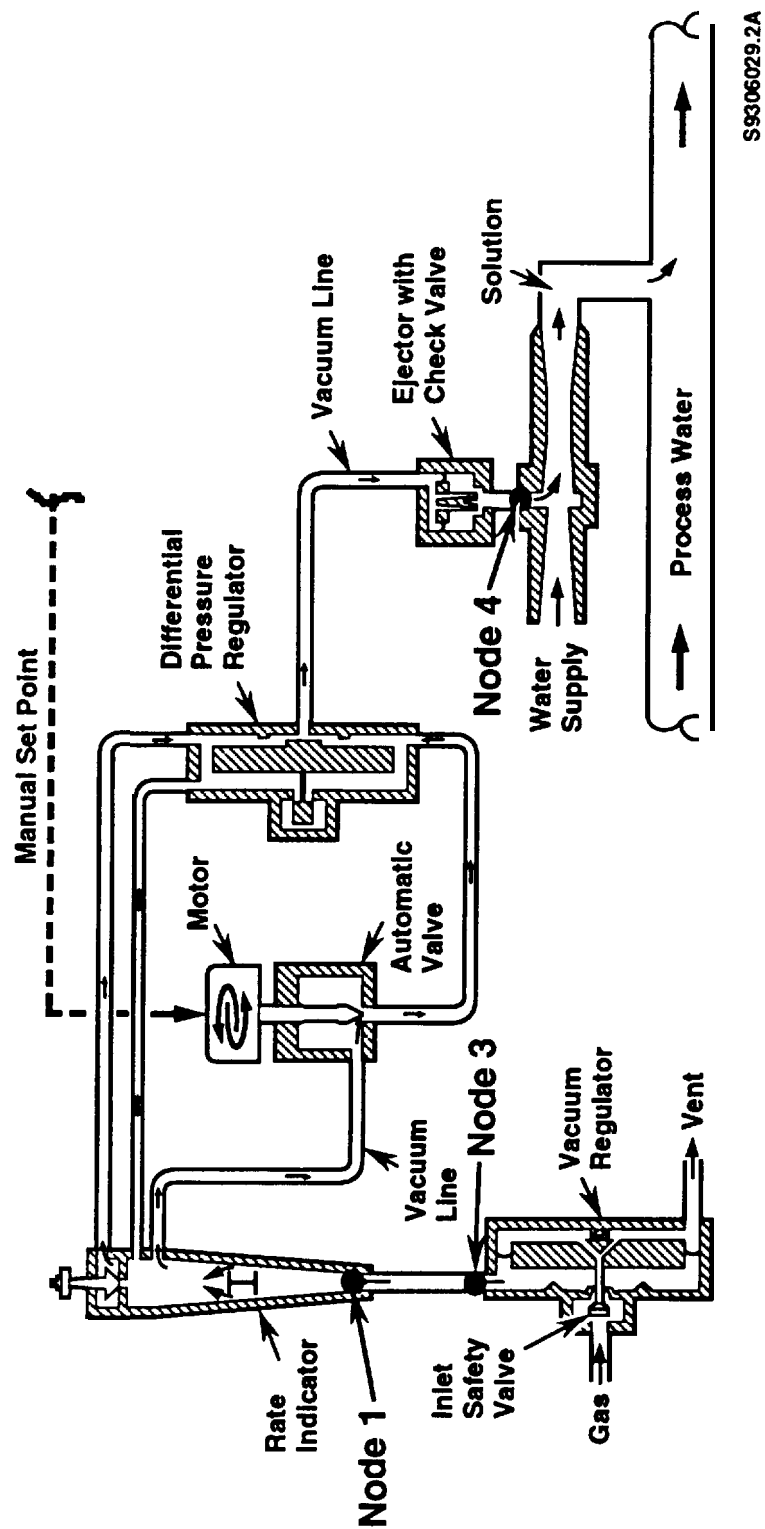


**Notes:**

- Position depends on which chlorinator or cylinder and/or chlorine supply line is in-service
- NO - Normally open  
NS - Normally shut

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Figure RI. Chlorination Process, Study Nodes 2 and 4



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**Figure B-2.** Chlorination Process, Study Nodes 1, 3, and 4

<b>PLANT/OPERATION:</b> Water Treatment Facility / Chlorination Process <b>LINE/VESSEL/NODE:</b> Node 1 <b>DESIGN INTENTION:</b> Transfer Cl <sub>2</sub> Vapor to Rotameter 20-60 lbs/day at 26-inch mercury vacuum at 65°F through ambient				<b>REVIEW DATE:</b> 5/18/93 <b>DRAWING NO.:</b> Automatic Gas Feed System (Figure B-2) <b>REVIEW TEAM:</b> K. Agee, J. Rude, S. Camp, F. Leverenz, K. Murphy, S. Kanth, D. Ortiz, J. Angyus, P. Pelto, J. Piatt, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCE-NARIO	ACTION / COMMENTS
No	No Flow	Valve closed (G-1, G-5, G-7, G-9, and G-13). . Failed closed. . Inadvertently closed, [ -HF: valves located close to each other   +HF: flow directions indicated by valve position; valve handles different.] Poly line crimped by activity (e.g., maintenance) in area.  Screen blocked in regulator on cylinder.	Decreased Cl <sub>2</sub> residual in water, violates state code (WAC 246-290). (Takes 1-2 hours to occur.)  If continued undetected, a bacterial problem could result with illness across the site (within a day).	1) Automatic switch-over if the valves G-1 and G-5 are closed. 2) High vacuum alarm; the operator diagnoses and restores the system if possible. [ -HF: many potential causes for this alarm; no procedures for diagnosis   + HF: time for diagnosis is long; rotameter flow indication aids diagnosis.] 3) Low Cl <sub>2</sub> residual during surveillance. a) The filter plant is checked every 2 hrs. b) The tour operator checks around the grid (at 12 points/shift). [ -HF: operator normally adjusts Cl <sub>2</sub> flow via controller, could try to adjust for low Cl <sub>2</sub> without noticing rotameter is at no flow   + HF: several checks by different operators before consequence occurs.] Mitigation: Restrict usage of potable water when low Cl <sub>2</sub> is detected,	1-1	Sufficient protection.
More	More flow	No causes in this segment.			1-2	
Less	Less flow	Valves partially closed (same valves as #1-1).	Same as #1-1 (no flow), except it would take longer.	Same as Protection in #1 -1, 1) and 2) (if vacuum from restricted flow is high enough), and 3).	1-3	Protection sufficient.

<b>PLANT / OPERATION:</b> Water Treatment Facility / Chlorination Process <b>LINE/VESSEL/NODE:</b> Node 1 <b>DESIGN INTENTION:</b> Transfer Cl <sub>2</sub> Vapor to Rotameter 20-60 lbs/day at 26-inch mercury vacuum at 65°F through ambient				<b>REVIEW DATE:</b> 5/1 8193 <b>DRAWING NO.:</b> Automatic Gas Feed System (Figure B-2) <b>REVIEW TEAM:</b> K. Agee, J. Rude, S. Camp, F. Leverenz, K. Murphy, S. Kanth, D. Ortiz, J. Angyus, P. Pelto, J. Piatt, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCE-NARIO	ACTION / COMMENTS
Reverse	Reverse flow	Valve S-1 closed. . Failed closed. . Inadvertently closed, {—HF: valves located close to each other   + HF: flow direction indicated by valve position; valve handles different.}	Water enters the chlorine vapor system with damage to equipment and seals and there is potential for leaks later if it is not repaired: • “In” leakage of air when operating ejector • Small “out” leakage of Cl <sub>2</sub> when vacuum from ejector is interrupted; minor irritation if staff present.	1 ) Check valve at ejector. 2) Low vacuum alarm. {—HF: new potential causes for this alarm; no procedure for diagnosis}. 3) Same protection as #I-1, 3).	1-4	Check on possibility of backflow past rotameter and respond accordingly by modifying administrative procedures.
More	High Temperature	No causes in this segment.			1-5	
Less	Low temperature	No causes for temperature low enough to cause a problem.			1-6	
More	High pressure	No causes in this segment.			1-7	
Less	Low pressure	No causes in this segment.			1-8	
As well as	Air into C1 <sub>2</sub>	Leak in polyethylene tubing/pipe, valve stem, etc, (Replacement of tubing every two years reduces the likelihood of failure. )  Potential for dissimilar material to thermally expand or contract from temperature extremes.	Low Cl <sub>2</sub> for water treatment.  If continued undetected, a bacterial problem could result with illness across the site.	Check of Cl <sub>2</sub> residuals during surveillance may detect. a) The filter plant is checked every 2 hrs. b) The tour operator checks around the grid (at 12 points/shift). {—HF: operator normally adjusts Cl <sub>2</sub> flow via controller, could try to adjust for low Cl <sub>2</sub> without noticing rotameter is set no flow   + HF: several checks by different operators before consequence occurs.} <b>Mitigation: Restrict usage of potable water when low C1<sub>2</sub> is detected.</b>	1-9	Consider adding procedures that verify the vacuum holds after system shutdown (to be use when tubing is replaced and chlorinators are changed each month).

LANT/OPERATION: Water Treatment Facility / Chlorination Process				REVIEW DATE: 5/1 8/93		
INE/VESSEL/NODE: Node 1				DRAWING NO.: Automatic Gas Feed System (Figure B-2)		
DESIGN INTENTION: Transfer Cl <sub>2</sub> Vapor to Rotameter 20-60 lbs/day at 26-inch mercury vacuum at 65°F through ambient				REVIEW TEAM: K. Agee, J. Rude, S. Camp, F. Leverenz, K. Murphy, S. Kanth, D. Ortiz, J. Angyus, P. Pelto, J. Piatt, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCE-NARIO	ACTION / COMMENTS
As well as (cont. )	Air into Cl <sub>2</sub>	Leak in polyethylene tubing/pipe, valve stem, etc. (Replacement of tubing every two years reduces the likelihood of failure. )	Potential for damage to seals/corrosion from HCl forming due to moisture in air,  Same as #1-4.	Operator to check rotameter every 2 hrs. Can visually detect air, if familiar with its appearance.  Vacuum gage on chlorinator may show decrease in vacuum. [—HF: these require operator with enough experience to recognize somewhat subtle indications; a "novice" not likely to detect. ]	1-10	Minor consequences.
		Leak in system after replacement of tubing. [—HF: no procedure written for replacement of tubing, or system integrity verification after replacement.]	Same as #1-9 and #1-10.	Same as #1-9 and #1-10.	1-11	Same as #1-9 and #1-10.
Part of	No meaningful deviations					

<b>PLANT/OPERATION:</b> Water Treatment Facility / Chlorination Process <b>LINE/VESSEL/NODE:</b> Node 1 <b>DESIGN INTENTION:</b> Transfer Cl <sub>2</sub> Vapor to Rotameter 20-60 lbs/day at 26-inch mercury vacuum at 65°F through ambient				<b>REVIEW DATE:</b> 5/1 8193 <b>DRAWING NO.:</b> Automatic Gas Feed System (Figure B-2) <b>REVIEW TEAM:</b> K. Agee, J. Rude, S. Camp, F. Leverenz, K. Murphy, S. Kanth, D. Ortiz, J. Angyus, P. Pelto, J. Piatt, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCENARIO	ACTION / COMMENTS
Other human	Air into ejector	Line break (either poly break or schedule-80 steel break inside or outside of building). Maintenance activity could be the cause of failure, especially poly.	Loss of Cl <sub>2</sub> to water treatment (see #1-1 ).	1 ) Low vacuum alarm, may have Cl <sub>2</sub> alarm; the operator diagnoses and switches to alternate supply. [—HF: many potential causes for this alarm; no procedures for diagnosis. 2) Cl residual checks (See #7-1, Protection 3).	1-12	Low likelihood.
			Cl <sub>2</sub> release (up to 3/8-inch release). Potential for injuries and fatalities near 315 Building and neighboring buildings.	Regulator shuts off on loss of vacuum. Mitigation: Cl <sub>2</sub> alarm (local and remote). Site-wide emergency response (alarm designed for leaks inside building). "Chlorinator trouble alarm" (31 5 common alarm) with tour operator response.	1-13	Low likelihood. Cause and sufficient protection. Verify that the adjacent buildings have received information on chlorine in their HAZCOM program.



<b>LANT/OPERATION:</b> Water Treatment Facility / Chlorination Process  <b>LINE/VESSEL/NODE:</b> Node 2  <b>DESIGN INTENTION:</b> Storage cylinder provides $Cl_2$ gas to regulator at 65°F to ambient, approximately 75 psig to 150 psig (at 110°F); 20-60 lbs $Cl_2$ /day.				<b>REVIEW DATE:</b> 5/1 9193  <b>DRAWING NO.:</b> Chlorination Process Flow Diagram (Figure B-1 ) <b>REVIEW TEAM:</b> F. Leverenz, S. Camp, J. Rude, K. Agee, S. Kanth, K. Murphy, D. Ortiz, J. Angyus, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCENARIO	ACTIONS/COMMENTS
No	No $Cl_2$ provided	Tank is empty.	Same as #1-1.	Same as #1-1 and weight check.	2-1	Same as #1-1.
		Tank valve is closed.	Same as #1-1.	Same as #1-1.	2-2	Same as #1-1.
		Internal tank tubes are plugged/defective (blocked).	Same as #1-1.	Same as #1-1.	2-3	Same as #1-1.
More	More $Cl_2$ provided	No causes.				
Less	Less $Cl_2$ provided	Valve partially closed [—HF: valve does not readily indicate amount open.] Internal tank tubes partially plugged.	Same as #2-2 and 2-3 except takes longer to C C U r 99	Same as #2-2 and 2-3.	2-4	Same as #2-2 and 2-3.
More	High temperature	Heater fails “on” during summer heat.	If the temperature is greater than 160° F, the fusible link may release resulting in a $Cl_2$ release. Potential for injuries and fatalities near the 315 Building and neighboring buildings.	Tour operator notices high temperature in room during 2-hour check. [ + HF: operator would likely note temperature of 160° F in building.]  Mitigation: Same as #1 -13; cylinder repair kit to reduce size of release.	2-5	Calculate temperature based on heat input versus heat loss for this scenario. Base further recommendation items on the results,

<b>PLANT/OPERATION</b> Water Treatment Facility / Chlorination Process				<b>REVIEW DATE:</b> 5/1 9193		
<b>LINE/VESSEL/NODE:</b> Node 2				<b>DRAWING NO.:</b> Chlorination Process Flow Diagram (Figure B-1 )		
<b>DESIGN INTENTION:</b> Storage cylinder provides $\text{Cl}_2$ gas to regulator at 65°F to ambient, approximately 75 psig to 150 psig (at 11 O°F); 20-60 lbs $\text{Cl}_2$ /day.				<b>REVIEW TEAM:</b> F. Leverenz, S. Camp, J. Rude, K. Agee, S. Kanth, K. Murphy, D. Ortiz, J. Angyus, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCE-NARIO	ACTIONS / COMMENTS
More (cont.)		Fire  The following reduces the likelihood of a fire: <ul style="list-style-type: none"> <li>● Internal fire: no combustible or flammable materials are stored in the building,</li> <li>● External fire: there are no likely fire sources.</li> <li>● Housekeeping procedures are used to prevent combustible or flammable materials from entering the building.</li> </ul>	If fusible plug(s) work, release will occur via plug, If not, a BLEVE could result,  Same as #2-5.	None.	2-6	Fire is very unlikely.
Less	Low temperature	Heater fails in the winter/cold weather,	Potential reduction in $\text{Cl}_2$ feed rate; no significant consequence,		2-7	Minor consequences.
More	High Pressure	Cylinder is received overfilled.	Unknown	Check cylinder weight against the weight of a properly filled chlorine cylinder. [—HF: procedure requires operator to 'zero' weight for new cylinder; may not notice overweight.]	2-8	Check pressure potential from chlorine cylinder and the system (regulator) response. Determine whether the fusible plug will open with high pressure.
Less	Low pressure	Covered under low temperature (#2-7); no additional causes related to hazards.			2-9	
As well as	Other material added	$\text{Cl}_2$ contaminated.	Unknown		2-10	Check with vendor regarding possible contamination material for scenarios 2-10 and 2-11. Take appropriate recommendation/action.

PLANT / OPERATION: <b>Water Treatment Facility / Chlorination Process</b>				REVIEW DATE: <b>5/1 9193</b>		
LINE/VESSEL /NODE: <b>Node 2</b>				DRAWING NO.: <b>Chlorination Process Flow Diagram (Figure B-1 )</b>		
DESIGN INTENTION: <b>Storage cylinder provides Cl<sub>2</sub> gas to regulator at 65°F to ambient, approximately 75 psig to 150 psig (at 11 O°F); 20-60 lbs Cl<sub>2</sub>/day.</b>				REVIEW TEAM: <b>F. Leverenz, S. Camp, J. Rude, K. Agee, S. Kanth, K. Murphy, D. Ortiz, J. Angyus, R, Hansen</b>		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCE-NARIO	ACTIONS/COMMENTS
Other than	Another material loaded	Cylinder contains something other than chlorine (e. g., sulfur dioxide uses same size container),	Unknown		2-11	See above.
Part of	No meaningful deviations					

<b>PLANT/OPERATION:</b> Water Treatment Facility/Chlorination Process <b>LINE/VESSEL/NODE:</b> Node 3 <b>DESIGN INTENTION:</b> Provide $\text{Cl}_2$ from storage cylinder to vacuum line at 25 inches of Hg at 65°F to ambient with 20-60 lb./day.				<b>REVIEW DATE:</b> 5/1 9193 <b>DRAWING NO.:</b> Automatic Gas Feed System (Figure B-2) <b>REVIEW TEAM:</b> F. Leverenz, S. Camp, J. Rude, K. Agee, S. Kanth, K. Murphy, D. Ortiz, Joe Angyus, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCENARIO	ACTIONS / COMMENTS
No	No flow	Broken diaphragm, stuck open relief valve, or leak in vacuum side of regulator occurs.	Loss of $\text{Cl}_2$ flow (same as #1-12).	Same as #1-9.	3-1	Consider #1 -9 recommendation; would need to close the $\text{Cl}_2$ cylinder block valve.
More	More flow	Regulator fails open.	Release of $\text{Cl}_2$ through the relief valve and vent (same as #1-13). Potential for injuries/fatalities near the 315 Building and neighboring buildings.	None.  Mitigation: $\text{Cl}_2$ alarm (local and remote). Site-wide emergency response (alarm designed for leaks inside building). "Chlorinator trouble alarm" (31 5 common alarm) with tour operator response.	3-2	The cause seems to have a low likelihood. The vendor should be contacted to determine the failure experience (corrosion, water, etc. ). If cause seems more likely after investigation, controls such as remote shutoff at $\text{Cl}_2$ cylinder (and power fail-safe) should be considered.
Less	Low flow	Regulator doesn't open far enough.	Same as #2-4,	Same as #2-4 .	3-3	Same as #2-4.
Reverse	Reverse flow	No causes in this segment.			3-4	
More	High temperature	No causes this segment,			3-5	
Less	Low temperature	No causes this segment.			3-6	
More	High pressure	No additional causes (see 3-2).			3-7	
Low	Low pressure	No additional causes (see 3-3).			3-8	
Part of	No meaningful deviation this segment				3-9	

<b>PLANT/OPERATION:</b> Water Treatment Facility / Chlorination Process				<b>REVIEW DATE:</b> 5/1 9193		
<b>LINE/VESSEL/NODE:</b> Node 3				<b>DRAWING NO.:</b> Automatic Gas Feed System (Figure B-2)		
<b>DESIGN INTENTION:</b> Provide Cl <sub>2</sub> from storage cylinder to vacuum line at 25 inches of Hg at 65°F to ambient with 20-60 lb./day.				<b>REVIEW TEAM:</b> F. Leverenz, S. Camp, J. Rude, K. Agee, S. Kanth, K. Murphy, D. Ortiz, Joe Angyus, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCENARIO	ACTIONS /COMMENTS
As well as	Material in the atmospheric side of the regulator	Sand, water, bugs, dust, etc.	Blocked vent line; if an over-pressure event occurs (3-2) the vacuum line could become over-pressured; the vacuum line may not hold under pressure (same as #1-13).	Vent screen will protect somewhat (same as xl-13).	3-10	Verify that the screen is in place.

PLANT/OPERATION:	Water Treatment Facility / Chlorination Process	REVIEW DATE:	5/19/93
LINE/VESSEL/NODE:	Node 4	DRAWING NO.:	Automatic Gas Feed System and Chlorination Process Flow Diagram (Figures B-1 and B-2)
DESIGN INTENTION:	Provide gas to ejector at 25 inches of Hg, vacuum, 20-60 lb/day, 65°F to ambient	REVIEW TEAM:	F. Leverenz, S. Camp, J. Rude, K. Agee, S. Kanth, K. Murphy, D. Ortiz, Joe Angyus, R. Hansen

GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCE-NARIO	ACTIONS/COMMENTS
No	No flow	Motor-controlled rate valve closed. . Failed closed. • Operator closes rate control valve inadvertently. [+ HF: "up/down" keypad with digital readout display of position.] Ejector check valve failed closed.  Valves plugged by dirt.	Same as #1-1.	Same as #1-1.	4-1	Protection sufficient,
More	More flow	Rotameter opened too far. . Rate valve opened too far. [− HF: possible error in residual sample or calculation • Operator does not reset to a lower value when the demand decreases. [− HF: operators depend on memory to complete actions.1 . PLC controller fails.	Objectionable tastes/vapors in the water.	1) Operator checks visual flow on rotameter at tank. [− HF: operator usually relies on digital is not likely used to using rotameter flow indication.] 2) Surveillance of "residuals" (see Protection 3) for #1-1.	4-2	Minor consequence.

<b>PLANT /OPERATION:</b> Water Treatment Facility / Chlorination Process <b>LINE/VESSEL/NODE:</b> Node 4 <b>DESIGN INTENTION:</b> Provide C1 to ejector at 25 inches of Hg, vacuum, 20-60 lb/day, 65°F to ambient				<b>REVIEW DATE:</b> 5/19/93 <b>DRAWING NO.:</b> Automatic Gas Feed System and Chlorination Process Flow Diagram (Figures B-1 and B-2) <b>REVIEW TEAM:</b> F. Leverenz, S. Camp, J. Rude, K. Agee, S. Kanth, K. Murphy, D. Ortiz, Joe Angyus, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCENARIO	ACTIONS /COMMENTS
Less	Less flow	Plugged ejector.  Rota meter closed too much, • Rate valve not opened enough. [-HF: possible error in residual sample or calculation ] + HF: "up/down" key pad with digital readout display of position]. • Operator does not reset to a higher value when the demand increases. [-HF: operators depend on memory to complete actions.] • PLC controller fails.	Same as #1-3.	Same as #1 -3.	4-3	Sufficient protection.
More/less	High or low pressure	Differential pressure regulator.	Unknown		4-4	How the differential pressure regulator operates is unknown. The valve's operation should be checked and the potential for a pressure deviation should be assessed.

LANT/OPERATION: Water Treatment Facility / Chlorination Process LINE/VESSEL/NODE: Node 4 DESIGN INTENTION: Provide $\sim 5$ to ejector at 25 inches of Hg, vacuum, 20-60 lb/day, 65°F to ambient				REVIEW DATE: 5/1 9/93 DRAWN(3 NO.: Automatic Gas Feed System and Chlorination Process Flow Diagram (Figures B-1 and B-2) REVIEW TEAM: F. Leverenz, S. Camp, J. Rude, K. Agee, S. Kanth, K. Murphy, D. Ortiz, Joe Angyus, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCE-NARIO	ACTIONS/COMMENTS
More	High temperature	Chlorinator heater fails "on" in summer,	Possible water pipe rupture if the temperature exceeds the PVC's strength, Small chlorine release (no health effects expected),	None.	4-5	Minor consequences.
			PLC operational limits. The PLC could malfunction if temperature is too high (see less/more flow scenario, #1-2 and #1-3).	Same as #1-2 and #1 -3.	4-6	(PLC operating range: 14° F-122° F,) Protection sufficient (#1 -3) and minor consequences (#1 -2).
Less	Low temperature	Heater fails during cold weather [winter].	Out-of-service water pipe breaks (water freezes in the line).	The operator's 2-hour check of the facility. [— HF: operator may not note cracked/broken line while it is still frozen   + HF: operator will likely note temperature of building is low.]	4-7	Minor consequences.
			Safety shower and eye wash freezes. There is potential for more serious injury if an incident occurs during unavailability.	Safety shower and eye wash lines are heat traced.	4-8	Low likelihood that an incident occurs the same time freezing occurs.
Part of	No meaningful deviation					
As well as	Air into chlorine vacuum line	Leak in the line/fittings: potential for dissimilar material to thermally expand or contract from temperature extremes.	Same as #1-9 and #1-10.	Operator check of chlorine residuals, (Same as Protection 3 of #1 -1).	4-9	Same as #1-9 and #1-10.
Reverse	Reverse flow	Already covered #1-4.			4-10	Same as #1-4.



<b>PLANT / OPERATION:</b> Water Treatment Facility / Chlorination Process <b>LINE / VESSEL / NODE:</b> Node 4 <b>DESIGN INTENTION:</b> Provide $\text{Cl}_2$ to ejector at 25 inches of Hg, vacuum, 20-60 lb/day, 65°F to ambient				<b>REVIEW DATE:</b> 5/1 9/93 <b>DRAWING NO.:</b> Automatic Gas Feed System and Chlorination Process Flow Diagram (Figures B-1 and B-2) <b>REVIEW TEAM:</b> F. Leverenz, S. Camp, J. Rude, K. Agee, S. Kanth, K. Murphy, D. Ortiz, Joe Angyus, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCENARIO	ACTIONS / COMMENTS
Other than	Air only into injector	Line break in vacuum line.	Same as #1-12.	Same as #1-12.	4-11	Same as #1-12.
None	No level	Chlorine tank failure (e.g., structural flaw).	Release of contents. Potential for injury and fatalities of staff in the surrounding area.	None,  Mitigation: $\text{Cl}_2$ alarm (local and remote). Site-wide emergency response (alarm designed for leaks inside building), "Chlorinator trouble alarm" (31 5 common alarm) with tour operator response.	4-12	Low likelihood.
No	Loss of utility (off-site power)	Loss of electric power; water pumps discontinue operating. (Loss of vacuum to chlorinator).	$\text{Cl}_2$ is release through the vent,  $\text{Cl}_2$ contacts back flow preventers with potential damage to equipment.  Up to 3/8-inch leak with potential for injuries and fatalities near 315 Building and neighboring buildings.	Regulator safety valve,  Mitigation: (Same as #4-12).	4-13	Note: the detector has battery backup and an alarm on standby power,  Verify that the monthly PM includes checking the backup battery for the chlorine alarm.  Note: there are plans to put water pumps on standby power, which will make this "cause" less likely,

<b>PLANT/OPERATION:</b> Water Treatment Facility / Procedures <b>LINE/VESSEL/NODE:</b> Node 5 <b>DESIGN INTENTION:</b> Removing Empty Chlorine Cylinder (west cylinder)				<b>REVIEW DATE:</b> 5/20193 <b>DRAWING NO.:</b> Procedures for the Change-out of Chlorine Cylinders (see Appendix A) <b>REVIEW TEAM:</b> F. Leverenz, S. Camp, J. Rude, K. Agee, S. Kanth, K. Murphy, D. Ortiz, J. Angyus, J. Piatt, R. Hansen		
Guide Words without meaningful deviations have been omitted from this table.						
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCE-NARIO	ACTIONS/COMMENTS
(1) Notify the 384 Powerhouse and the Hanford Fire Department that the chlorine cylinder change-out is in progress.						
No	Skip step	Supervisor does not notify.	May increase response time/readiness of personnel because of no advanced warning. False response upon disconnect of regulator resulting in C <sub>1</sub> alarm (Step 1 1)0	None,	5-1	Minor consequences.
(2) Start the 3 15B Building vent fan and operate it for 3 minutes before entering. Maintain the vent fan continuously.						
No/less	Skip step. (Operate less than 3 min. )	The C <sub>1</sub> plant operator does not start the fan,	Possible exposure if a leak exists and the detector failed,  Possible irritation with low likelihood of injury.	Detector malfunction alarm alerts operator that detector has failed. [—HF: operator may proceed and assume no Cl <sub>2</sub> is present.]	5-2	Low likelihood.
(3) Enter through the walk-through door.						
	No meaningful deviation				5-3	

<b>PLANT/OPERATION:</b> Water Treatment Facility / Procedures <b>LINE/VESSEL/NODE:</b> Node 5 <b>DESIGN INTENTION:</b> Removing Empty Chlorine Cylinder (west cylinder) Guide Words without meaningful deviations have been omitted from this table.				<b>REVIEW DATE:</b> 5/20/93 <b>DRAWING NO.:</b> Procedures for the Change-out of Chlorine Cylinders (see Appendix A) <b>REVIEW TEAM:</b> F. Leverenz, S. Camp, J. Rude, K. Agee, S. Kanth, K. Murphy, D. Ortiz, J. Angyus, J. Piatt, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCENARIO	ACTIONS/COMMENTS
(4) Identify the empty cylinder by its weight, and verify the indication of no flow on the cylinder regulator.						
No	Skip step	C1 <sub>2</sub> plant operator does not check cylinder weight and or indication of no flow.	If the wrong cylinder is selected, there is loss of C1 <sub>2</sub> to the chlorinator (same as #1-1).	1) At Step 5 an alarm is received on loss of vacuum. [–HF: may assume this is a normal alarm for change-out of cylinder.] 2) Hoisting and rigging crew notices that tank is heavier than normal. [+HF: crew is experienced in change-out of cylinder.] 3) At Step 9 alarm does not clear. [–HF: 'reverse' indication is more likely to be misinterpreted.]	5-4	Minor consequences.
			Release of contents of full cylinder at Step 11.  Injury/potential fatality of the plant operator.  Injury/fatality potential in nearby buildings.	1) At Step 5 cylinder valve is closed. 2) At Step 8 the chlorinator flow is checked. Actuated alarm has been checked. 3) At Step 11 plant operator checks for leaks when removing regulator [–HF: this step requires judgement on how to remove to detect that tank is still open.]  Mitigation: personal protective equipment.  Mitigation: observer radios HAZMAT team; emergency response initiated.	5-5	Protection sufficient.

<b>PLANT/OPERATION:</b> Water Treatment Facility / Procedures <b>LINE/VESSEL/NODE:</b> Node 5 <b>DESIGN INTENTION:</b> Removing Empty Chlorine Cylinder (west cylinder) <b>Guide Words</b> without meaningful deviations have been omitted from this table.				<b>REVIEW DATE:</b> 5/20/93 <b>DRAWING NO.:</b> Procedures for the Change-out of Chlorine Cylinders (see Appendix A) <b>REVIEW TEAM:</b> F. Leverenz, S. Camp, J. Rude, K. Agee, S. Kanth, K. Murphy, D. Ortiz, J. Angyus, J. Piatt, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCE-NARIO	ACTIONS /COMMENTS
<b>(5) Close the angle (root) valve on the chlorine cylinder.</b>						
No	Skip step	Cl <sub>2</sub> plant operator does not close the valve.	Release of the remaining cylinder contents at Step 11.  Injury to plant operator.  Injury to staff in nearby buildings.	1 ) Step 8 chlorinator flow checked/alarm actuated. 2) Step 11 slowly disconnect regulator and check for leaks.  Mitigation: personnel protective equipment.  Mitigation: observer radios hazmat team; emergency response initiated.	5-6	Sufficient protection.
Less	Valve partially closed.	Plant operator does not close the valve completely. [—HF: valve provides no indication of position.]	Lesser consequence than #5-6.  Injury to plant operator.	At Step 11 check for leaks at disconnect. [—HF: MW as #5-5, 3).]  Mitigation: Personal protection equipment.	5-7	Sufficient protection.
Reverse	Valve opened all the way	Plant operator opens rather than closes the valve. [—HF: valve provides no indication of position, and full open 'feels' like full closed.]	Same as #5-6.	Same as #5-6.	5-8	Sufficient protection.
<b>(6) Isolate the automatic switch-over valve. (Close valves G5, G6, and G9).</b>						
No	Skip step	Plant operator skips step.	At Step 11 when disconnect slightly larger release of Cl <sub>2</sub> .  Minor irritation.	At Step 8, flow/vacuum alarm check.	5-9	Sufficient protection.

<b>PLANT/OPERATION:</b> Water Treatment Facility / Procedures <b>LINE/VESSEL/NODE:</b> Node 5 <b>DESIGN INTENTION</b> Removing Empty Chlorine Cylinder (west cylinder) Guide Words without meaningful deviations have been omitted from this table.				<b>REVIEW DATE:</b> 5120/93 <b>DRAWING NO.:</b> Procedures for the Change-out of Chlorine Cylinders (see Appendix A) <b>REVIEW TEAM:</b> F. Leverenz, S. Camp, J. Rude, K. Agee, S. Kanth, K. Murphy, D. Ortiz, J. Angyus, J. Piatt, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCE-NARIO	ACTIONS/COMMENTS
(7) Verify that valves <b>G8</b> and <b>G4</b> are closed.						
No	Skip step	Plant operator skips this step.	No consequences.		5-10	No consequences.
(8) Verify that valve <b>G1</b> is open, and open valve <b>G3</b> . Wait 2 minutes and verify that there is no flow at the chlorinator in service. Verify that the high-vacuum alarm is actuated.						
No	Skips step	Plant operator skips this step.	Same as #5-9.	1 ) Slow disconnect and leak check at Step 11. [—HF: see #5-5, 3).]  Mitigation: personal protective equipment.	5-11	Sufficient protection.
Less	Less time	Plant operator proceeds without waiting 2 min.	Lesser consequence than #5-n,	1 ) Flow check at chlorinator. 2) High vacuum alarm at Step 11, 3) Slow disconnect and leak check at Step 11. [—HF: see #5-5, 3).]  Mitigation: personal protective equipment,	5-12	Sufficient protection.
Part of	Skips check on step	Plant operator skips "checks" of vacuum alarm and flow.	Loss of protection for this step and for previous steps,	None.	5-13	No direct consequence.
	Skips opening G3	Plant operator does not open G3.	Same as #5-11.	Same as #5-12.	5-14	Sufficient protection.

PLANT/OPERATION: Water Treatment Facility / Procedures LINE/VESSEL/NODE: Node 5 DESIGN INTENTION Removing Empty Chlorine Cylinder (west cylinder) Guide Words without meaningful deviations have been omitted from this table.				REVIEW DATE: 5/20/93 DRAWING NO.: Procedures for the Change-out of Chlorine Cylinders (see Appendix A) REVIEW TEAM: F, Leverenz, S. Camp, J. Rude, K. Agee, S. Kanth, K. Murphy, D. Ortiz, J. Angyus, J. Piatt, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCENARIO	ACTIONS/COMMENTS
(9) Close valves G 1 and G3. Open valves G6 and G9, and verify that the high-vacuum alarm clears.						
No	Skips step.	Plant operator skips this step.	Same as #1-12 when line opened at Step 11.	Low vacuum alarm occurs at Step 11.	5-15	Minor consequence,
Part of	Skips closing valves.	Plant operator does not close G1 and G3. [-HF: valves close together and easy to confuse.]	At Step 11 air is introduced into the system, reducing chlorination.	Low vacuum alarm occurs at Step 11.	5-16	Minor consequence.
	Skips opening valves.	Plant operator does not open G6 and G9. [-HF: same as #5-16.]	Same as #1-1.	1 ) High vacuum alarm does not clear. 2) Cl residual checks (see #/-1, Protection 3).	5-17	Protection sufficient,
Other than	Wrong valves are opened.	Plant operator opens G5 and G9. [-HF: an% as #5-16.]	Same as #5-15.	Same as #5-15.	5-18	Minor consequence.
(10) Chlorine serviceman dons the facemask respirator, and operator dons self-contained breathing apparatus (SCBA). Then they verify the operation of the personal protective equipment.						
No	Skip step	Neglect to wear the personal protective equipment.	Loss of protection for scenarios where needed.	Observer reminds serviceman of need for personal protective equipment,	5-20	No direct consequence.

<b>PLANT / OPERATION:</b> Water Treatment Facility / Procedures <b>LINE / VESSEL / NODE:</b> Node 5 <b>DESIGN INTENTION:</b> Removing Empty Chlorine Cylinder (west cylinder) <b>Guide Words without meaningful deviations have been omitted from this table.</b>				<b>REVIEW DATE:</b> 5/20/93 <b>DRAWING NO.:</b> Procedures for the Change-out of Chlorine Cylinders (see Appendix A) <b>REVIEW TEAM:</b> F. Leverenz, S. Camp, J. Rude, K. Agee, S. Kanth, K. Murphy, D. Ortiz, J. Angyus, J. Piatt, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCE-NARIO	ACTIONS/COMMENTS
(11) Slowly disconnect the regulator, check it for leaks, and set it on the floor.						
No	Skip step	Serviceman does not disconnect the regulator.	Hoses could be broken if cylinder is moved at Step 13. Small release; minor irritation,	Observation that regulator is still connected,	5-21	Minor consequences.
Part of	Skip part of step.	Serviceman does not open slowly while checking for leaks. [ -HF: experience required to judge "slowly" and to differentiate between a leak and residual Cl <sub>2</sub> in the line.]	Loss of protection in previous scenarios,	None,	5-22	No direct consequence.
As well as	Unwanted action	Serviceman drops regulator after disconnect.	Damage regulator; possible "cause" for scenario in re-connection.	Serviceman alerts operations supervisor of drop.	5-23	No direct consequence.
Other than	Wrong cylinder	Serviceman selects the wrong cylinder.	Serviceman disconnects in-use cylinder with release of full cylinder contents (see 5-5).  Potential for injuries and fatalities near 315 Building and neighboring buildings.	1 ) Verify tank valves are closed. [ -HF: procedure does not require check of cylinder valve [ +HF: serviceman has considerable experience]. 2) Open slowly with ammonia check. [ -HF: see #5-5, 3, Protection.] 3) Low vacuum alarm and Cl <sub>2</sub> alarm. [ -HF: operator may assume this is normal alarms for disconnect.]	5-24	Sufficient protection.  Existing tagging system to be incorporated into disconnect procedures.

<b>PLANT/OPERATION:</b> Water Treatment Facility / Procedures <b>LINE/VESSEL/NODE:</b> Node 5 <b>DESIGN INTENTION:</b> Removing Empty Chlorine Cylinder (west cylinder) Guide Words without meaningful deviations have been omitted from this table.				<b>REVIEW DATE:</b> 5/20/93 <b>DRAWING NO.:</b> Procedures for the Change-out of Chlorine Cylinders (see Appendix A) <b>REVIEW TEAM:</b> F. Leverenz, S. Camp, J. Rude, K. Agee, S. Kanth, K. Murphy, D. Ortiz, J. Angyus, J. Piatt, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCE-NARIO	ACTIONS / COMMENTS
(12) Install the cap on the cylinder angle valve, and install the protective hood.						
No	Skip step	Serviceman does not install the cap,	Loss of protection for valves and threads during subsequent handling incidents.	Visual observation when cylinder is moved (Step 13).	5-25	Low likelihood.
(13) Position the crane and cylinder truck for loading; open the roll-up door; remove the chocks; and push the cylinder out to the stops.						
Reverse	Reverse part of step	Trucks are not in place when cylinder rolled out.	Possibility of vehicle impact with the cylinder resulting in release of $Cl_2$ . Potential injuries in the area.	None.	5-26	Low likelihood.
(14) Release the chain binders, and turn the cylinder over to the hoist and rigging crew.						
No	Skip step	Chain binders are not released,	Cannot load cylinder onto the truck; potential damage to the equipment.	Hoist crew notes that the chain is connected,	5-27	Minor consequence.
(15) Install the spreader bar, lift the cylinder, and place it on the flatbed truck.						Note: hoisting and rigging crew has detailed procedure.
Part of	Incomplete installation	Partially hooked,	The dropped cylinder is damaged resulting in a $Cl_2$ release. Same as #5-26.	Radio for hazmat support.	5-28	Low likelihood.
As well as	Unwanted action	Crane operator mishandles the cylinder lift.	Cylinder strikes object. Same as #5-28.	None.	5-29	Low likelihood.
Part of	Fails during lift	Crane or rigging fails (broken cables, etc.).	Same as #5-28.	Same as #5-28.	5-30	Low likelihood. Rigging is certified by non-destructive examination.



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LINE/VESSEL/NODE: Node 5				DRAWING NO.:	Procedures for the Change-out of Chlorine Cylinders (see Appendix A)	
DESIGN INTENTION: Removing Empty Chlorine Cylinder (west cylinder)				REVIEW TEAM:	F. Leverenz, S. Camp, J. Rude, K. Agee, S. Kanth, K. Murphy, D. Ortiz, J. Angyus, J. Piatt, R. Hansen	
Guide Words without meaningful deviations have been omitted from this table,						
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCE-NARIO	ACTIONS/COMMENTS
(16) Secure the cylinder and transport it.						
No	Skip step	Driver does not secure the cylinder.	The cylinder is released during transport (e.g., falls off truck). Potential for cylinder failure, Cl <sub>2</sub> release and injuries to people along the route.	None.	5-31	Low likelihood.
(17) Close the roll-up door, and exit through the walk-through door.						
No	Skip step	Plant operator does not close the doors.	May compromise effectiveness of Cl <sub>2</sub> detectors.	Tour operator surveillance,	5-32	Low likelihood.

<b>PLANT/OPERATION:</b> Water Treatment Facility / Procedures <b>LINE/VESSEL/NODE:</b> Node 6 <b>DESIGN INTENTION:</b> Install Replacement Chlorine Cylinder (west cylinder)				<b>REVIEW DATE:</b> 5/21 /93 <b>DRAWING NO.:</b> Procedures for the Change-out of Chlorine Cylinders (see Appendix A) <b>REVIEW TEAM:</b> F, Leverenz, J. Rude, S, Camp, D. Ortiz, J. Angyus, R. Hansen		
Guide Words without meaningful deviations have been omitted from this table.						
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCENARIO	ACTIONS/COMMENTS
(1) Turn on or verify that the storage room exhaust fan is on.						Note: Hoisting and rigging crew has detailed procedure.
No	Skip step	Plant operator does not turn the fan on.	Loss of prevention for Step 10 (entry of storage building).	Serviceman notes the fan is off before entry and turns it on. [—HF: ● rviceemm works on many different installations and may not think to check the fan.]	6-1	Insignificant consequences.
(2) Position the crane for unloading,						
Part of	Mis-positioned	Crane is mis-positioned (would require extreme mis-positioning).	Difficulty in moving cylinder to trolley; may delay replacement. It is possible that the cylinder could be damaged, Possible injuries and fatalities in area if release occurs from damage.	Other crew members,	6-2	Low likelihood. Crane has considerable flexibility.
(3) Position the chlorine transport truck for unloading,						
Part of	Mis-positioned	Truck is mis-positioned (would require extreme mis-positioning).	Same as #6-2.	Same as #6-2.	6-3	Low likelihood.

PLANT/OPERATION: Water Treatment Facility / Procedures LINE/VESSEL/NODE Node 6				REVIEW DATE: 5/21/93 DRAWING NO.: Procedures for the Change-out of Chlorine Cylinders (see Appendix A) REVIEW TEAM: F. Leverenz, J. Rude, S. Camp, D. Ortiz, J. Angyus, R. Hansen		
DESIGN INTENTION Install Replacement Chlorine Cylinder (west cylinder)						
Guide Words without meaningful deviations have been omitted from this table.						
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCE-NARIO	ACTIONS/COMMENTS
(4) Verify that tha chlorine cylinder trolley is in position to receive the cylinder.						
Part of	Mis-positioned	Trolley is mis-positioned and no correction occurs, (The worst case is when the trolley is off the track.)	Same as #6-2.  If it is off the track, it could roll. (The apron or concrete pad is sloped toward parking lot.) It would likely stop when the wheels run off the apron onto the gravel.	Same as #6-2.	6-4	Low likelihood,
(5) Release the cylinder binder(s) on the transport vehicle.						
No	Skip step	Driver does not release the binders.	Cannot remove the cylinder,	Hoist and rigging crew notice binder at Step 6.	6-5	Minor consequence.
Part of	Only one binder in place	Driver only releases one binder.	One end of cylinder moves the other does not, same as #6-5.	Same as #6-5.	6-6	Minor consequence.
(6) Install the lifting bar, and lift the cylinder.						
Part of	Incomplete installation	Same as #5-28.	Same as #5-28.	None,	6-7	Low likelihood,
(7) Place the cylinder on the trolley.						
Part of	Fails during lift	Crane or rigging fails (broken cables, etc.).	Same as #5-30.	None,	6-8	Low likelihood, Rigging is certified by non-destructive examination.
As well as	Unwanted action	Crane operator mis-handles lift.	Same as #5-29.	None,	6-9	Low likelihood.

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<b>LINE/VESSEL/NODE:</b>	Node 6	<b>DRAWING NO.:</b>	Procedures for the Change-out of Chlorine Cylinders (see Appendix A)
<b>DESIGN INTENTION</b>	Install Replacement Chlorine Cylinder (west cylinder)	<b>REVIEW TEAM:</b>	F. Leverenz, J. Rude, S. Camp, D. Ortiz, J. Angyus, R. Hansen
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GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCE-NARIO	ACTIONS / COMMENTS
(8) Remove the lifting bar, removing it from the immediate area.						
No	Skip step	Bar is not removed.	Delay in the replacement of the cylinder.	None,	6-10	Minor consequence.
(9) Secure the cylinder to the trolley with chain binders (2).						
No	Skip step	Plant operator does not install chain binders.	No consequences except chains dragging as trolley pushed into building.	Sound of dragging chains.	6-11	Low likelihood. Primary reason for chain binders as seismic precautions; seismic activity is small (below seismic probability of zone 2).
(10) Enter the walk-through door, and open the roll-up door.						
	No meaningful deviations					
(11) Push the trolley and the chlorine cylinder into the building and against the rail stop. Install the wheel chocks.						
No	Skip step	Plant operator does not move the cylinder.	Delay in replacement of cylinder.	Position noted by rest of staff.	6-12	Minor consequences.
Part of	Part of step skipped	Wheel chocks are not installed.	Precaution (against movement) not in place.	Missing chocks noted by staff during routine checks. [ -HF: chocks are not readily visible as they are under tank.]	6-13	No direct consequence.
	Not positioned	Plant operator does not push the cylinder (on trolley) in far enough.	When the regulator is installed lines are damaged by stretching. Low or no Cl <sub>2</sub> flows to the chlorinator when the cylinder is put in use (see also #I-9).	1 ) Serviceman notes the position and requires correction. [ +HF: position is noted when lines do not readily reach cylinder. ] 2) Step 19 leak check,	6-14	Sufficient protection.

<b>PLANT/OPERATION:</b>	Water Treatment Facility / Procedures	<b>REVIEW DATE:</b>	5121193
<b>JUNE/VESSEL/NODE:</b>	Node 6	<b>DRAWING NO.:</b>	Procedures for the Change-out of Chlorine Cylinders (see Appendix A)
<b>DESIGN INTENTION:</b>	Install Replacement Chlorine Cylinder (west cylinder)	<b>REVIEW TEAM:</b>	F. Leverenz, J. Rude, S. Camp, D. Ortiz, J. Angyus, R. Hansen
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GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCENARIO	ACTIONS / COMMENTS
(12) Request the chlorine serviceman to remove the protective hood from the chlorine cylinder.						
No	Skip step	Serviceman does not remove hood.	Delay in replacement.	Noted by staff,	6-15	
(13) Observe the position of cylinder angle valves. If the valves are not in vertical alignment, loosen the chain binders and rotate the cylinder to obtain vertical alignment, and then tighten the chain binders.						
No	Skip step	Serviceman does not vertically align the cylinder. [—HF: alignment done by observation of cylinder connections   + HF: serviceman has considerable experience with connections.]	Potential to for liquid chlorine to enter the ejector and over chlorinate; potential for Cl <sub>2</sub> release from the water.  Release potential unknown.		6-16	Consult the vendor on this scenario and the expected system response. Estimate the amount of Cl <sub>2</sub> release potential.
Part of	Part of step	Chains are not tightened after alignment.	No consequence expected.		6-17	No consequence expected.
(14) Chlorine serviceman dons the facemask respirator, and operator dons self-contained breathing apparatus (SCBA). Then they verify the operation of the personal protective equipment.						
No	Skip step	Neglect to wear personal protective equipment.	Loss of protection for scenarios where needed.		6-18	No direct consequence.
(15) Verify that the chlorine cylinder gas angle valve is closed.						
No	Skip step	Serviceman does not verify it is closed.	At Step 16, Cl <sub>2</sub> is released when the cap is removed if the valve is not fully closed.  Same as #5-5.	At Step 16, the cap is opened slowly while checking for leaks. [+ HF: serviceman experienced with importance of this check.]  Same mitigation as #5-5.	6-19	Sufficient protection.

PLANT/OPERATION: Water Treatment Facility / Procedures LINE/VESSEL/NODE: Node 6  DESIGN INTENTION: Install Replacement Chlorine Cylinder (west cylinder)  (Guide Words without meaningful deviations have been omitted from this table.)				REVIEW DATE: 5/21 /93 DRAWING NO.: Procedures for the Change-out of Chlorine Cylinders (see Appendix A) REVIEW TEAM: F. Leverenz, J. Rude, S. Camp, D. Ortiz, J. Angyus, R. Hansen		
GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCE-NARIO	ACTIONS / COMMENTS
(16) Check for leaks while slowly removing the protective cap from the cylinder gas angle valve.						
More/ Part of	Too fast/not check	Serviceman opens the cap too quickly or does not check for leaks. [+ HF: <del>serviceman</del> experienced with importance of <del>this</del> check. ]	If valve is open or leaking, the release of Cl <sub>2</sub> is possible (amount depends on valve opening).  Same as #5-5.	Mitigation: Cl <sub>2</sub> alarm with emergency response and same mitigation as #5-5.	6-20	Cause unlikely.
(17) Clean the sealing surface of the gas angle valve and the vacuum regulator. Visually inspect the regulator valve body for damage.						
No	Skip step	Serviceman does not clean/check sealing surface of angle valve or vacuum regulator,	Possible seal leak at Step 18 or leak from damaged regulator,  Cl <sub>2</sub> release at Step 19 same as #5-5,	Leak check at Step 19. [ + HF: <del>serviceman</del> experienced with importance of <del>this</del> check.]  Mitigation: Cl <sub>2</sub> alarm with emergency response and same mitigation as #5-5.	6-21	Low likelihood,
(18) Install a new lead seal. Attach the regulator to the cylinder gas valve, and secure it in place by tightening the yoke assembly.						
Part of	Incorrect lead seal installation	Serviceman does not install the lead seal or uses the old seal. [+ HF: experienced serviceman knows importance of <del>new</del> seal.]	Same as #6-21,	Same as #6-21.	6-22	Same as #6-21.
Less	Not tight enough	Serviceman does not tighten the yoke assembly enough, [+ HF: serviceman experienced with cylinder yoke attachment. 1	Same as #6-21,	Same as #6-21.	6-23	Same as #6-21.
More	Too tight	Serviceman over-tightens the yoke assembly. [ + HF: <del>serviceman</del> experienced with cylinder yoke attachment. ]	Breaks the yoke; replacement of cylinder is delayed.		6-24	Low likelihood.

<b>PLANT/OPERATION:</b> Water Treatment Facility / Procedures <b>LINE/VESSEL/NODE:</b> Node 6 <b>DESIGN INTENTION:</b> Install Replacement Chlorine Cylinder (west cylinder)				<b>REVIEW DATE:</b> 5/21/93 <b>DRAWING NO.:</b> Procedures for the Change-out of Chlorine Cylinders (see Appendix A) <b>REVIEW TEAM:</b> F. Leverenz, J. Rude, S. Camp, D. Ortiz, J. Angyus, R. Hansen		
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GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCENARIO	ACTIONS / COMMENTS
Other than	Wrong angle valve	Serviceman installs regulator on the liquid valve. [+ HF: serviceman experienced with attachment and must install upside down.]	Same as #6-16.	1 ) Same as #6-16. 2) Tour surveillance notices regulator upside down.	6-25	Low likelihood.
(19) Check for leaks. <b>Slowly</b> open the chlorine cylinder gas supply valve.						
Part of	Not check for leaks	Serviceman does not check for leaks.	Loss of protection in previous scenarios.		6-26	No direct consequence.
More	Opens too fast	Serviceman opens valve too fast.	Releases more chlorine than necessary for leak detection.  No health effects expected.	None.  Personal protective equipment for serviceman and operator.	6-27	Low likelihood.
(20) Adjust the cylinder weight scale to indicate 2,000 pounds of product available in the cylinder.						
	No meaningful deviations					
(21) Open system supply valves G-1 and G-5.						
No or Part of	Skip step or part of the step	Plant operator does not open the valves.	Replacement chlorine not available; loss of chlorination. Same as #1-1.	1 ) High vacuum alarm. 2) Residual Cl <sub>2</sub> surveillance checks (see also #1-1, Protection 3).	6-28	Sufficient protection.
Less	Not opened completely	Plant operator does not open one or both of the valves completely.	No consequence.		6-29	
Other than	Wrong valve selected	Plant operator opens the G3 valve instead of the G 5 valve. [—HF: several valves in one location.]	Draws Cl <sub>2</sub> from both cylinders at the same time. Potential for loss of chlorination (see #1 -1).	1 ) Surveillance checks weight of cylinders. 2) Surveillance checks rate indicators on regulators.	6-30	Minor consequences.

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GUIDE WORD	DEVIATION	CAUSE	CONSEQUENCES	PROTECTION	SCENARIO	ACTIONS/COMMENTS
(22) Record in the log book the chlorine cylinder identification number and the scale weight.						
	No meaningful deviations					
(23) Report any deficiencies to the supervisor for initiation of necessary corrective action.						
No	Skip step	Notification not made.	Delay in completing action.		6-31	Minor consequences,
(24) Notify the Hanford Fira Department and the 364 Powerhouse that the chlorine cylinder <b>change-out</b> activities are complete.						
No	Skip step	Notification not made.	No consequence.		6-32	Minor consequence.
(25) Close the roll-up door, and axit through the walk-through door.						
	No meaningful deviations					